APPLICATION NO. 10/772,597
INVENTION: Decisioning rules for turbo and convolutional decoding
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CLAIMS

WHAT IS CLAIMED IS:

Claim **1.**(currently amended) A method for performing a new turbo decoding algorithm using a-posteriori probability $p(s,s'|y)$ in equations **(13)** for defining the maximum a-posteriori probability MAP, comprising:

using a new statistical definition of the MAP logarithm likelihood ratio $L(d(k)|y)$ in equations **(18)**

$$L(d(k))|y) = \ln[\,\Sigma_{(s,s'|d(k)=+1)}\; p(s,s'|y)]$$
$$-\ln[\,\Sigma_{(s,s'|d(k)=-1)}\; p(s,s'|y)\,]$$

equal to the natural logarithm of the ratio of the a-posteriori probability $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,

using a factorization of the a-posteriori probability $p(s,s'|y)$ in equations (13) into the product of the a-posteriori probabilities

$$p(s,s'|y)=p(s|s',y(k))p(s|y(j>k))p(s'|y(j<k)),$$

using a turbo decoding forward recursion equation

$$p(s|y(j<k),y(k)) = \Sigma_{\text{all } s'}\; p(s|s',y(k))\; p(s'|y(j<k))$$

for evaluating said a-posteriori probability $p(s'|y(j<k))$ in equations (14) using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s′ at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of the user data bits d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k),

using a turbo decoding backward recursion equation

$$p(s'|y(j>k-1)= \Sigma_{\text{all } s}\, p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posteriori probability $p(s|y(j>k))$ in equations (15) using said $p(s'|s,y(k))= p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s \rightarrow s'$ to the new state s′ at k-1 from the previous state s at k and given said observed symbol y(k) to update these recursions for said assumed value of d(k),

evaluating the natural logarithm of the state transition posteriori probability $p(s|s',y(k))=p(s'|s,y(k))$ equal to a new decisioning metric DX in equations (11),(16), defined by equation

$$\begin{aligned} \ln[p(s|s',y(k)) &= \ln[p(s'|s,y(k))] \\ &= \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k)) \\ &= DX \end{aligned}$$

wherein $\underline{p}$ is the natural logarithm ln of p, x* is the complex conjugate of x, and ln[o] is the natural logarithm of [o],

whereby said new state transition probabilities in said MAP equations use said DX linear in y(k) in place of the current use of the maximum likelihood decisioning metric

$DM=[\ -|y(k)\ -\ x(k)|^2/2\sigma^2\ ]$ which is a quadratic function of y(k),

whereby said MAP turbo decoding algorithms provide some of the performance improvements demonstrated in FIG. **5,6** using said DX, and

whereby this new a-posteriori mathematical framework enables said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said y(k).

Claim **2.** (currently amended) A method for performing a new convolutional decoding algorithm using the MAP a-posteriori probability $p(s,s'|y)$ in equations (13), comprising::

using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

using the factorization of the a-posteriori probability $p(s,s'|y)$ in equations (13) into the product of said a-posteriori probabilities $p(s'|y(j<k))$, $p(s|s',y(k))$, $p(s|y(j>k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$\begin{aligned} p_k(s|s') &= p(s|s',y(k)) \\ b_k(s) &= p(s|y(j>k)) \\ a_{k-1}(s') &= p(s'|y(j<k)), \end{aligned}$$

using a convolutional decoding forward recursion equation in

equations (14) for evaluating said a-posteriori probability $a_k(s)=p(s|y(j<k),y(k))$ using said $p_k(s|s')=p(s|s',y(k))$ as said state transition probability of the trellis transition path $s'\rightarrow s$ to the new state s at k from the previous state s′ at k-1,

using a convolutional decoding backward recursion equation in equations (15) for evaluating said a-posteriori probability $b_k(s)=p(s|y(j>k))$ using said $p_k(s'|s)=p(s'|s,y(k))$ as said state transition probability of the trellis transition path $s\rightarrow s'$ to the new state s′ at k-1 from the previous state s at k,

evaluating the natural logarithm of said state transition a-posteriori probabilities

$$\begin{aligned}\ln[p_k(s'|s)] &= \ln[p(s'|s,y(k))]\\ &= \ln[p(s|s',y(k))]\\ &= \ln[p_k(s|s')]\\ &= DX\end{aligned}$$

equal to a new decisioning metric DX in equations (16), and

implementing said convolutional decoding algorithms to obtain some of the performance improvements demonstrated in FIG. **5**,**6** using said DX.

Claim **3**. (currently amended) Wherein in claim **2** a method for implementing the new convolutional decoding recursive equations, said method comprising:

implementing in equations (14) a forward recursion equation for evaluating the natural logarithm, $\underline{a}_k$, of a_k using the natural logarithm of the state transition a-posteriori probability $\underline{p}_k=\ln[p(s|s',y(k))]$ of the trellis transition

path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1, which is equation

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + \underline{p}_k(s|s')]$$

$$= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')]$$

$$= \max_{s'} [\underline{a}_{k-1}(s') + Re[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]$$

wherein said $DX(s|s') = \underline{p}_k(s|s')] = \underline{p}_k(s'|s) = DX(s'|s) = DX$ is a new decisioning metric, and

implementing in equations (15) a backward recursion equation for evaluating the natural logarithm, $\underline{b}_k$. of b_k using the natural logarithm of said state transition a-posteriori probability $\underline{p}_k = \ln[p(s'|s,y(k))] = \ln[p(s|s',y(k))]$ of the trellis transition path $s \rightarrow s'$ to the new state s' at k-1 and is equation

$$\underline{b}_{k-1}(s') = \max_{s} [\underline{b}_k(s) + DX(s'|s)].$$